Dawson Field Grazing Study

(Funding from US–Dept. Energy, Sep 2000 to Sep 2003)

Rationale

Tall fescue is the dominant cool-season grass in the Southeast, because it tolerates the long, hot summers better than other forages and is of generally high quality during late autumn and early spring. Quality of tall fescue, however, is compromised in late spring and summer by the production of ergot alkaloids through the association with an endophyte, *Neotyphodium coenophialum*. Most of the stands of tall fescue in the USA are infected with this fungus. Animals consuming these alkaloids have poorer animal performance and productivity compared with animals consuming tall fescue with the endophyte removed, resulting in symptoms of fescue toxicosis, fescue foot, and fat necrosis. Ecologically, however, the endophyte imparts positive attributes towards tall fescue yield and stand persistence. As part of this ecological impact, organic C concentration was found to be 13±8% higher in the upper 15 cm of soil under tall fescue with high compared with low endophyte infection. Making a choice between high endophyte infection–poor animal productivity and low endophyte infection–poor plant persistence is not easy for cattle producers, because they do not yet have good recommendations that quantify long-term production, ecological, and economic impacts of these choices.

A tall fescue genotype with high endophyte infection, but low alkaloid levels has been recently developed and made available to our research team. This genetic source provides an exciting opportunity to discern the effects of endophyte infection from those of alkaloid production on animal production and performance, stand persistence, and soil and water quality. For example, this new genotype could impart the ecological strategies of stand persistence because of the presence of the endophyte, but since it does not produce high quantities of alkaloids, it may contribute to high animal performance and productivity. On the other hand, deletion of alkaloid production from the endophyte genome could destroy its ecological strategies for survival.

In addition to cattle production, farms in the southeastern USA produce large numbers of poultry. The majority of broilers in the USA are produced in the same region where tall fescue is grown. Therefore, tall fescue pastures are often fertilized with litter cleaned from nearby poultry houses. Poultry litter can be a valuable resource in maintaining and restoring soil productivity by providing a wide range of nutrients and organic matter. It is often an economical alternative to inorganic fertilizer. However, continuous application of poultry litter to supply plant N requirements can lead to excessive nutrient loading of P, Cu, and Zn and may potentially contribute to nutrient and fecal-borne pathogenic contamination of surface waters. Additionally, both poultry litter and endophyte-infected tall fescue are sources of endocrine disruptors (e.g., testosterone in poultry litter, alkaloids in tall fescue) that could negatively impact cattle health on the pasture and human and wildlife health that might consume water from receiving bodies. There is an urgent need for quantitative information on the interactive effects of tall fescue plant source and fertilizer source on water quality, especially with regard to N, P, endocrine disruptors, and fecal-borne pathogen concentrations.

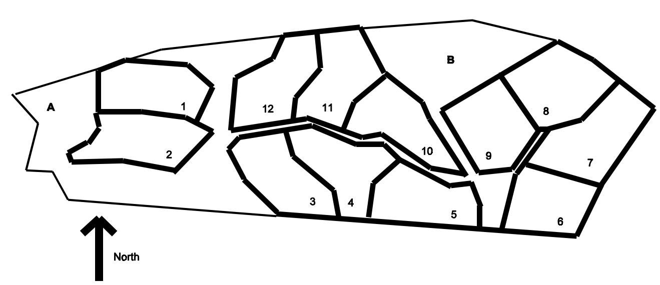
On a national level, utilization of pastures can result in a significant reduction in greenhouse gas emissions, by reducing both CH_4 emissions from ruminant animals consuming high-quality forage and sequestering CO_2 from the atmosphere as soil organic C. Quantitative information is conspicuously lacking on the rate of SOC accumulation under grazed tall fescue with different genetic characteristics and receiving different fertilizer sources. This information is urgently needed so that agricultural producers can receive potential C credits, if policy makers agree to limit greenhouse gas emissions under the Kyoto Protocol.

Objectives

1 Determine the annual and long-term animal responses (i.e., performance, productivity, behavior, animal days, calving rate) to the interactive effects of tall fescue genetic source and fertilizer source.
2 Determine the plant responses (i.e., stand, composition, alkaloid production, endophyte infection) of different genetic sources to fertilizer source with time.
3 Determine the soil responses (i.e., organic C, microbial biomass, particulate organic matter, surface residues, pH, inorganic N, available P and K, bulk density, aggregation, water infiltration) to the interactive effects of tall fescue genetic source, fertilizer source, and within-paddock animal behavior.
4 Determine the water runoff characteristics (i.e, total quantity, peak flow, N and P concentration, turbidity, pathogens, alkaloids, hormones) from outlets as affected by plant genetic and fertilizer sources.
5 Determine the internal parasite responses (i.e., total number, types of species, seasonal dynamics) within cattle as affected by plant genetic and fertilizer sources.
6 Determine the fate and survival in soil and runoff water of fecal-borne pathogens applied via poultry litter.
7 Assess the relationships between soil quality and water quality under cool-season grazing management.
8 Use this experiment in conjunction with the P-watershed study (i.e., cropping with poultry litter application) to compare water runoff characteristics under different land uses.
9 Use this experiment in conjunction with the Salem Road study (i.e., warm- and cool-season forage base) to assess animal, soil, and internal parasite responses.

Study area

Corner of Hog Mountain Road and Cliff Dawson Road on North Unit



Layout of Dawson Field experiment.

Experimental design

As experimental variables, we will plant three genetic sources of tall fescue:

- E+A8: high endophyte–high alkaloid (cv. Jessup Improved)
- E+A9: high endophyte–low alkaloid (Max Q Jessup)
- E!A9: low endophyte–low alkaloid (cv. endophyte-free Jessup Improved)

each fertilized with two different sources of nutrients:

- inorganic
- poultry litter

The experimental design will be a randomized, split-plot design. Subplots (3 plant genetic sources) will be arranged within whole plots (2 fertilizer sources) and replicated twice. Fertilizer will be applied at the rate of 200-40-100 kg N-P_2O_5-K_2O · ha^{-1} · yr^{-1} for the inorganic fertilizer source and at the rate of 6.6 Mg · ha^{-1} · yr^{-1} (i.e., 3 tons · $acre^{-1}$ · yr^{-1}; -270-100-140 kg N-P_2O_5-K_2O · ha^{-1} · yr^{-1}) for the poultry litter source in split applications made in Feb/Mar and in Sep/Oct. Each paddock is -1 ha with berms around perimeters to confine water movement within the paddock and an outlet to monitor water runoff.

Outputs / technology transfer

Publications will be forthcoming most likely in the period, 2003-2006.

Investigators / responsibilities

John Stuedemann (Dwight Seman): animal productivity, animal performance, stocking adjustment, available forage, mineral salts, internal parasites

Alan Franzluebbers (Steve Knapp): shallow and deep soil sampling, fertilizer applications, plant composition, water infiltration, laboratory analyses of soils for bulk density, total C and N, microbial biomass C, mineralizable C and N, water-stable aggregation, particulate organic C and N, inorganic N and P;
(Eric Elsner): site infrastructure development and maintenance, animal handling and care
(Robert Martin): inorganic N analyses (168 shallow soil/year, 252 deep soil/year), inorganic P analysis (168 shallow soil/year), total CNS (336 shallow soil/year, 252 deep soil/3 years), water analyses for NH_4, NO_3, PO_4, and DOC (? 500/year)

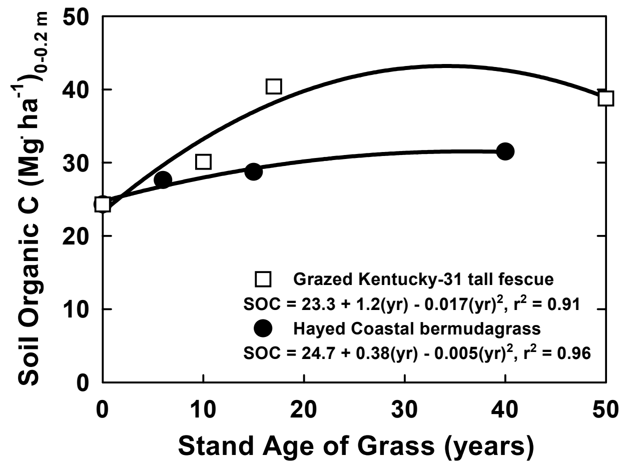
Dinku Endale (Steve Norris): installing flumes and water collectors, total water runoff, precipitation, GIS mapping of catchments, collecting water samples

Mike Jenkins (Shaheen Humayoun): collection of cattle feces and poultry litter for ribotyping, detecting fecal-borne pathogens in runoff water samples

Nick Hill (UGA): collect tall fescue samples and analyze for endophyte infection and alkaloid levels throughout year

Ray Kaplan (UGA): collection of fecal samples, determine parasite species and animal infection rates

Roger Burke (US-EPA): analyze soil samples for isotopic composition of soil organic matter fractions



Data from Franzluebbers et al. (2000; *Soil Biology & Biochemistry* 32:469-478). Although grazing increases soil organic C because of return of feces to the same field rather than forage removal with haying, endophyte-infected tall fescue may offer more than double the soil organic C sequestration rate as hybrid bermudagrass. This hypothesis will be tested by comparing data collected in the Dawson Field experiment with that collected from the Salem Road experiment.

Soil properties (0-15 cm depth) under tall fescue as affected by endophyte infection level. Data from Franzluebbers et al. (1999; *Soil Science Society of America Journal* 63:349-355).

	Endophyte level		
Soil property	High		Low
Total organic C (Mg · ha^{-1})	31.2	**	29.1
Potentially mineralizable C (kg · ha^{-1} · d^{-1})	48.5	*	53.9
Ratio of mineralizable-to-total	1.56	**	1.87

* and ** are significant at P#0.1 and P#0.01, respectively.